EXPLOITING TUNABLE VACUUM ULTRAVIOLET PHOTOIONIZATION COMBINED WITH REFLECTRON TIME-OF-FLIGHT MASS SPECTROMETRY FOR THE ISOMER-SPECIFIC DETECTION OF COMPLEX ORGANIC MOLECULES FORMED VIA INTERACTION OF IONIZING RADIATION WITH MIXED ASTROPHYSICAL ICE ANALOGUES

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Over 200 molecules have been detected in the interstellar medium (ISM) with close to one third considered to be complex organic molecules (COMs), molecules containing six or more atoms. Gas-phase reaction networks of ion-molecule and neutral-neutral reactions have aided in the understanding of the evolution of the interstellar medium (ISM). However, these models fail to explain the synthesis of ubiquitous COMs with predicted abundances several orders of magnitude lower compared to observations in the ISM, such as in Sagittarius B2. Over the last decades astrophysical laboratory simulation experiments have shown that some of these COMs are formed via interaction of ionizing radiation within simple ices deposited on interstellar dust particles at $10\,\mathrm{K}$ (H_2O, CH_3OH, CO, CO_2, CH_4, NH_3). After processing the ice temperature programmed desorption was utilized to sublime the ice along with its newly formed products for analysis with single photon vacuum ultraviolet ionization coupled with a reflectron time-of-flight mass spectrometer (PI-ReTOF-MS). The use of PI-ReTOF-MS allows for the selective ionization and identification of structural isomers of COMs. Here, we report that the key COMs propynal (HCCCHO) and cyclopropenone ($c-C_3H_2O$), which have both been detected in the ISM, can be synthesized within interstellar ices containing carbon monoxide (CO) and acetylene (C_2H_2) at temperatures as low as $5\,\mathrm{K}$. This is accomplished via non-equilibrium chemistry induced by the energetic electrons simulating those produced by galactic cosmic rays penetrating interstellar ices. Furthermore, cyclic COMs may act as tracers for non-equilibrium chemical processes at $10\,\mathrm{K}$ involving electronically excited reactants such as acetylene in excited triplet state(s). The incorporation of solid state data from these experiments, such as yield, branching ratio, and chemical and temperature conditions, into astrochemical models accounting for non-equilibrium has been shown to greatly improve predicted abundances.